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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

# WARTIME REPORT

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THE KNOCK-LIMITED PERFORMANCE OF FUEL BLENDS CONTAINING  
SPIROPENTANE, METHYLENECYCLOBUTANE, DI-tert-BUTYL  
ETHER, METHYL tert-BUTYL ETHER, AND TRIPTANE

By Carl L. Meyer

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Cleveland, Ohio

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NACA RB No. E6D22

## NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

## RESTRICTED BULLETIN

## THE KNOCK-LIMITED PERFORMANCE OF FUEL BLENDS CONTAINING

SPIROPENTANE, METHYLENECYCLOBUTANE, DI-tert-BUTYLETHER, METHYL tert-BUTYL ETHER, AND TRIPTANE

By Carl L. Meyer

## INTRODUCTION

A general investigation is being conducted at the NACA Cleveland laboratory to determine the effectiveness of various compounds as antiknock agents for aviation fuels. As a part of this program, limited quantities of spiropentane, methylenecyclobutane, and di-tert-butyl ether were synthesized for exploratory tests. Methyl tert-butyl ether and triptane, which had been commercially obtained, were used for comparative purposes. Knock-limited tests were made in a 17.6 engine of blends containing each of the five compounds individually blended with S-4 reference fuel to a concentration of 20 percent by volume; the final blends contained 4 ml TEL per gallon. The data were obtained in August 1945.

## APPARATUS AND TEST PROCEDURE

A description of the apparatus is given in reference 1. The tests were conducted with a 17.6 engine at the following engine conditions:

Engine speed, rpm . . . . .	1800
Compression ratio . . . . .	7.0
Outlet-coolant temperature, °F . . . . .	212
Inlet-air temperature, °F . . . . .	250, 100
Spark advance, deg B.T.C. . . . .	30

## PRESENTATION AND DISCUSSION OF RESULTS

The knock-limited performance at an inlet-air temperature of 250° F of leaded blends containing spiropentane and methylenecyclobutane is presented in figure 1; the knock-limited performance at

inlet-air temperatures of 250° F and 100° F of leaded blends containing di-tert-butyl ether, methyl tert-butyl ether, and triptane is presented in figure 2. All data at a given inlet-air temperature were obtained during a single operating day. The data of figures 1 and 2 are summarized in table I.

The 20-percent addition of spiropentane (fig. 1) decreased the knock-limited power of the base fuel at all fuel-air ratios below 0.085 but permitted gains at richer fuel-air mixtures. Methylene-cyclobutane decreased the knock-limited power of the base fuel at all fuel-air ratios below 0.112. Because of the lack of material, knock-limited performance data were not obtained for the spiropentane blend at fuel-air ratios greater than 0.10; additional tests to determine the effect of a change in inlet-air temperature on the knock-limited performance of either of the two aforementioned blends were not possible for the same reason.

Di-tert-butyl ether, methyl tert-butyl ether, and triptane (fig. 2) increased the knock-limited power of the base fuel at all fuel-air ratios and at both inlet-air temperatures. Methyl tert-butyl ether was the most effective antiknock agent of the three compounds. Di-tert-butyl ether was more effective than triptane at fuel-air ratios below 0.07 at the higher inlet-air temperature and at all fuel-air ratios at the lower inlet-air temperature. (Under other test conditions, reference 2 showed that di-tert-butyl ether had better antiknock qualities than methyl tert-butyl ether at fuel-air ratios below about 0.065.) Blends containing the three compounds are more sensitive at fuel-air ratios of 0.065 and 0.07 to changes in inlet-air temperature (table I(b)) than the base fuel; methyl tert-butyl ether was the most sensitive in the aforementioned fuel-air-ratio range.

Aircraft Engine Research Laboratory,  
National Advisory Committee for Aeronautics,  
Cleveland, Ohio.

#### REFERENCES

1. Meyer, Carl L., and Branstetter, J. Robert: The Knock-Limited Performance of Fuel Blends Containing Aromatics. Part I - Toluene, Ethylbenzene, and p-Xylene. NACA ARR No. E4J05, 1944.
2. Alquist, Henry E., and Tower, Leonard K.: Suitability of Ethers as Aviation Fuel Components. The Knock-Limited Performance of Several Ethers Blended with AN-F-28 Fuel. NACA CB No. E5A04, 1945.

TABLE I - SUMMARY OF TEST DATA

[17.6 engine; compression ratio, 7.0; engine speed, 1800 rpm; spark advance, 30° B.T.C.; outlet-coolant temperature, 212° F]

## (a) Relative performance

Compound	Blend composition (percent by volume)		Tetraethyl lead (ml/ gal)	imep ratio <sup>a</sup>				
				Fuel-air ratio				
	Compound	S-4		0.065	0.07	0.085	0.10	0.11
Inlet-air temperature, 250° F								
S-4 reference fuel	0	100	4	1.00	1.00	1.00	1.00	1.00
Spiropentane	20	80	4	0.84	0.86	1.00	1.09	----
Methylenecyclobutane				.77	.81	.89	.95	0.99
Di- <u>tert</u> -butyl ether				1.19	1.15	1.14	1.16	1.17
Methyl <u>tert</u> -butyl ether				1.26	1.25	1.37	1.45	1.47
Triptane				1.14	1.15	1.20	1.21	1.19
Inlet-air temperature, 100° F								
S-4 reference fuel	0	100	4	1.00	1.00	1.00	1.00	1.00
Di- <u>tert</u> -butyl ether	20	80	4	1.28	1.26	1.23	1.20	1.19
Methyl <u>tert</u> -butyl ether				1.40	1.42	1.41	1.41	1.40
Triptane				1.19	1.21	1.17	1.15	1.16

$$^a \text{imep ratio} = \frac{\text{imep (20 percent compound + 80 percent S-4 + 4 ml TEL/gal)}}{\text{imep (S-4 + 4 ml TEL/gal)}}$$

## (b) Relative temperature sensitivity

Compound	Blend composition (percent by volume)		Tetraethyl lead (ml/ gal)	Relative temperature sensitivity <sup>a</sup>				
				Fuel-air ratio				
	Compound	S-4		0.065	0.07	0.085	0.10	0.11
S-4 reference fuel	0	100	4	1.00	1.00	1.00	1.00	1.00
Di- <u>tert</u> -butyl ether	20	80	4	1.08	1.10	1.08	1.03	1.02
Methyl <u>tert</u> -butyl ether				1.11	1.14	1.03	.97	.95
Triptane				1.04	1.05	.98	.95	.97

<sup>a</sup>Relative temperature

$$\text{sensitivity} = \frac{\text{imep ratio (inlet-air temperature, 100° F)}}{\text{imep ratio (inlet-air temperature, 250° F)}}$$

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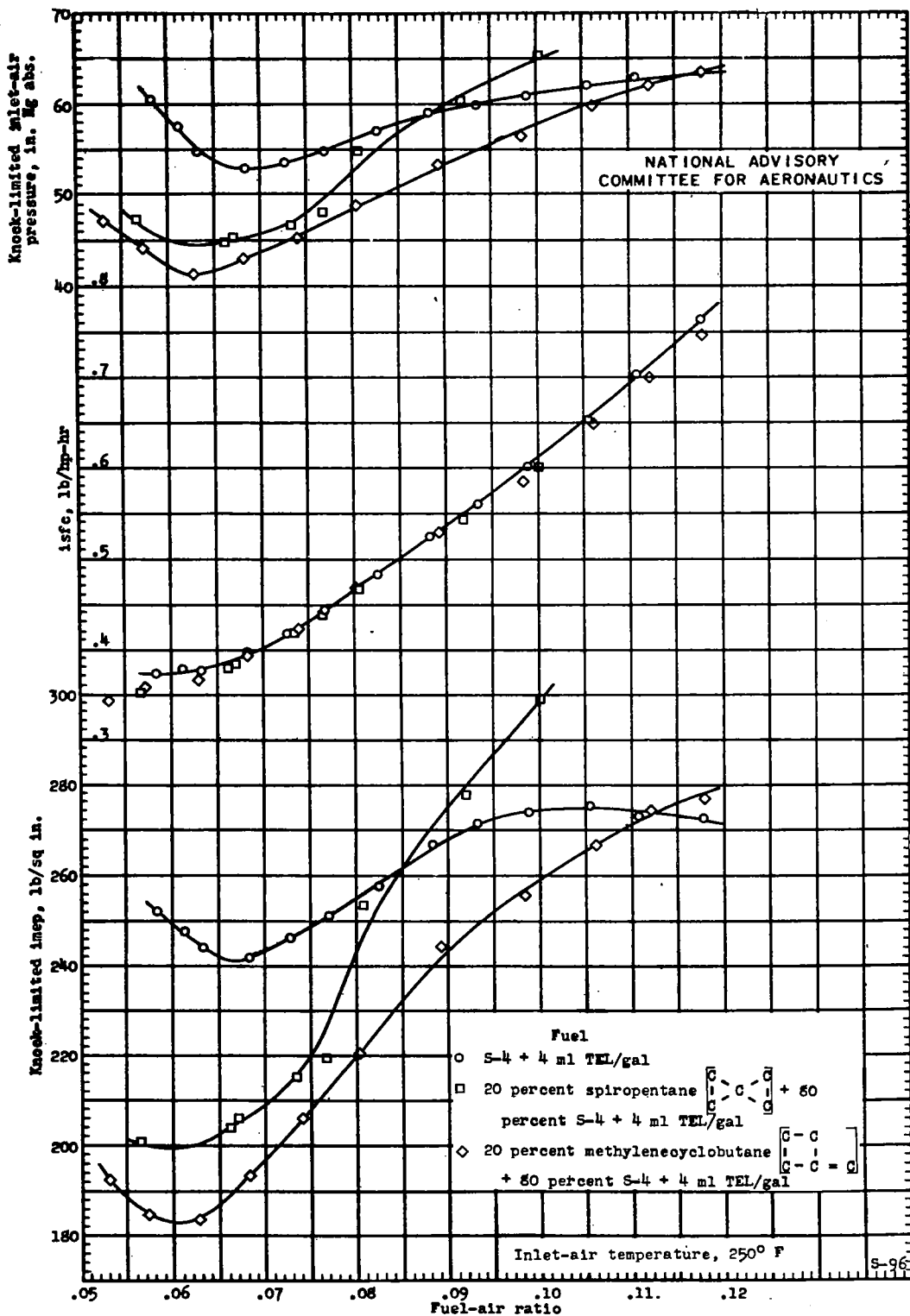


Figure 1. - The knock-limited performance of leaded blends containing spiropentane and methylenecyclobutane individually blended with S-4 reference fuel. 17.6 engine; compression ratio, 7.0; engine speed, 1800 rpm; spark advance, 30° B. T. C.; outlet-coolant temperature, 212° F.

Fig. 2

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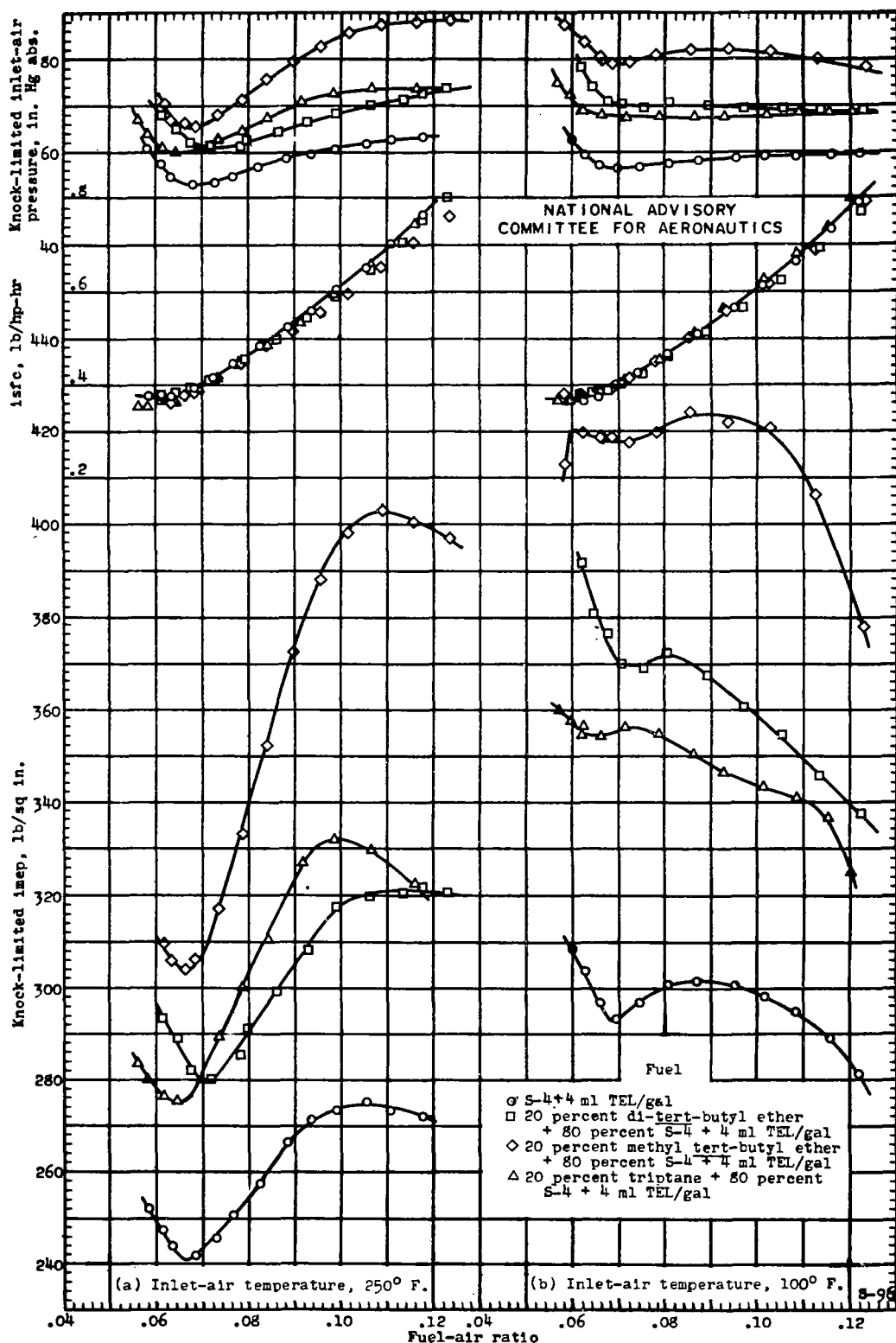


Figure 2. - The knock-limited performance of leaded blends containing di-tert-butyl ether, methyl tert-butyl ether, and triptane individually blended with S-4 reference fuel. 17.6 engine; compression ratio, 7.0; engine speed, 1800 rpm; spark advance, 30° B. T. C.; outlet-coolant temperature, 212° F.

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SECTION: Analysis and Testing (8)

CROSS REFERENCES: Fuel, Antiknock - Testing (42622);  
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U.S.	Eng.	.	Restr.	May'46	5	3	table, graph

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